ADMS 4 Complex Terrain Validation
Tracy Power Plant

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1 Introduction

The Tracy Power Plant is situated 27 km east of Reno, Nevada, in a region of complex terrain. The power plant is in a valley surrounded by peaks rising to around 950 m above the power plant elevation. During 1984, the United States Environmental Protection Agency carried out a series of 14 experiments between August 6th and 27th, for a total of 128 hours of data collection, mainly during the late evening and early morning hours [1].

The power plant was maintained in warm stand-by status as a tracer gas (SF_6) was released from the 91-m stack on the power plant, and concentrations were measured at 110 receptors (**Figure 1**). The majority of the receptors were positioned on high areas of the terrain, and around 20 were located within the valley. Different combinations of receptors were used for each of the experiments.

Meteorological data were measured at an instrumented 150-m tower located 1.2 km east of the plant. Wind speed, temperature and vertical turbulence parameter data were profile obtained from [2]. The observed data available included hourly average concentrations of SF_6 at each receptor point and meteorological data for each hour of each experiment.

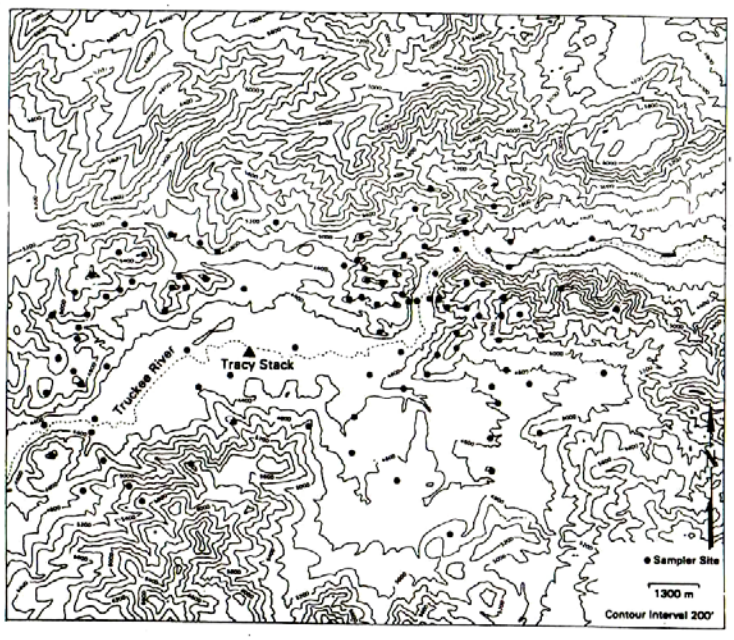

Figure 1 − Deployment of tracer sampling sites for the Tracy power plant study[1].

[1] **Figure 1** has been directly taken from the document [1].

This document compares the results of ADMS 4.1.0.0 (hereafter referred to as ADMS 4.1) with those of ADMS 4.2.2.0 (hereafter referred to as ADMS 4.2).

Section 2 describes the input data used for the model. The results are presented in Section 3 and discussed in Section 4.

2 Input data

2.1 Study area

The roughness length was 0.1 m, the surface albedo 0.25, the Priestley-Taylor parameter 0.6 and the latitude used in the runs was 40°N. The terrain file was created from Digital Elevation Model (DEM) data and covers a 17 km × 16 km area (as shown in **Figure 2**) with a resolution of approximately 230−240 m.

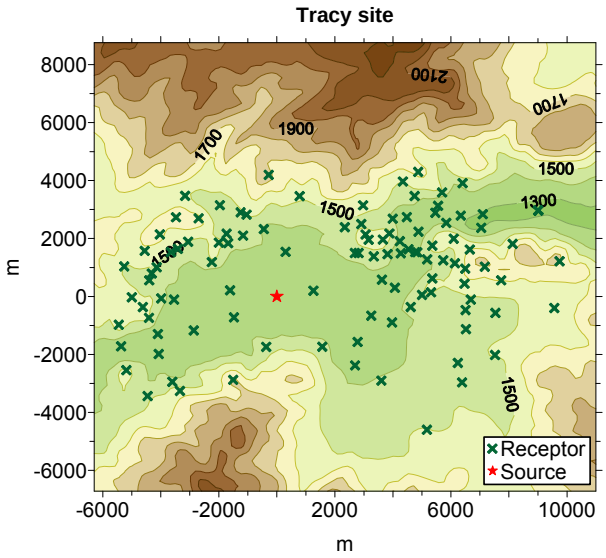

Figure 2 − The terrain surrounding the Tracy power plant, with the source location indicated by a star and receptor locations by black dots. Heights given in metres.

2.2 Source parameters

The source parameters are summarised in **Table 1**. The exit velocity varied from 6.8 to 23.2 m/s and the exit temperature from 22.2 to 110.0°C. The SF_6 emission rate (Q) varied between 1.2 and 1.5 g/s during the experiments, but an emission rate of 1 g/s was used for all of the modelled hours, so that the output concentrations (C) are normalized (C/Q) for direct comparison with the observed normalised values.

Pollutant	Location	h (m)	V (m/s)	T (°C)	D (m)	Q (g/s)
SF_6	(0,0)	90.95	varied	varied	2.74	1

Table 1 − Source input parameters. h is the stack height, V the exit velocity, T the exit temperature, D the diameter and Q the emission rate.

2.3 Receptors

Concentrations were calculated at all 110 receptors used in the tracer experiment (see **Figure 2**). The height of the majority of the receptors was 0.5 m above ground level. Three elevated receptors were positioned at heights of 43 m, 105 m and 145 m on a tower, which was located approximately 1.2 km east of the source.

2.4 Meteorological data

Meteorological data were collected from an instrumented 150-m tower located 1.2 km east of the power plant. Measurements were recorded at 15 heights, ranging from 10 m to 375 m.

The wind speeds and direction data used to create the meteorological file were those corresponding to a height of 100 m, in order to best represent the dispersion conditions at the height of the stack (see the wind rose shown in **Figure 3**). Inspection of **Figures 2** and **3** shows that that most of the wind comes from the south west, up the valley, towards the Tracy power station. The ambient temperatures ranged from 12.2 to 29.6°C.

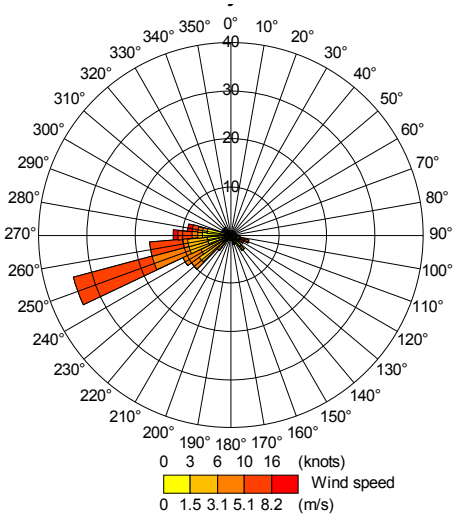

Figure 3 − Wind rose from meteorological data (wind measured at 100 m high).

In the meteorology data file, the minimum height of the boundary layer was set to 75 m. The value of the minimum wind speed (at a height of 10 m) to be used by the model was set to 0.5 m/s, in order to ensure that the low wind speed conditions were modelled.

In addition to the meteorological file, a profile file was created and used in the model run. It incorporates the wind speed, temperature and vertical turbulence parameter data measured at the 15 heights (10, 50, and every 25 m until 375 m).

3 Results

When comparing the observed and modelled concentrations, SF_6 ambient background values were subtracted from the observed results, assuming that the C/Q value[2] corresponding to the

[2] C = concentration in $\mu g/m^3$, Q = emission rate in g/s.

background levels was 0.011 μs/m^3, which was the smallest value present in the observed data.

In Section 3.1, results are presented as scatter plots and quantile-quantile plots of model results versus observed data. The results for all modelled hours are presented together. The data was also processed using the BOOT statistical package, and these results are given in Section 3.2.

3.1 Scatter and quantile-quantile plots

The scatter plots and quantile-quantile plots are given in **Figures 4** to **8** for all receptors, for the ground-level receptors and for each elevated receptor. Note that these quantile-quantile plots are linear; care should be exercised when comparing these plots with similar ones presented with logarithmic axes.

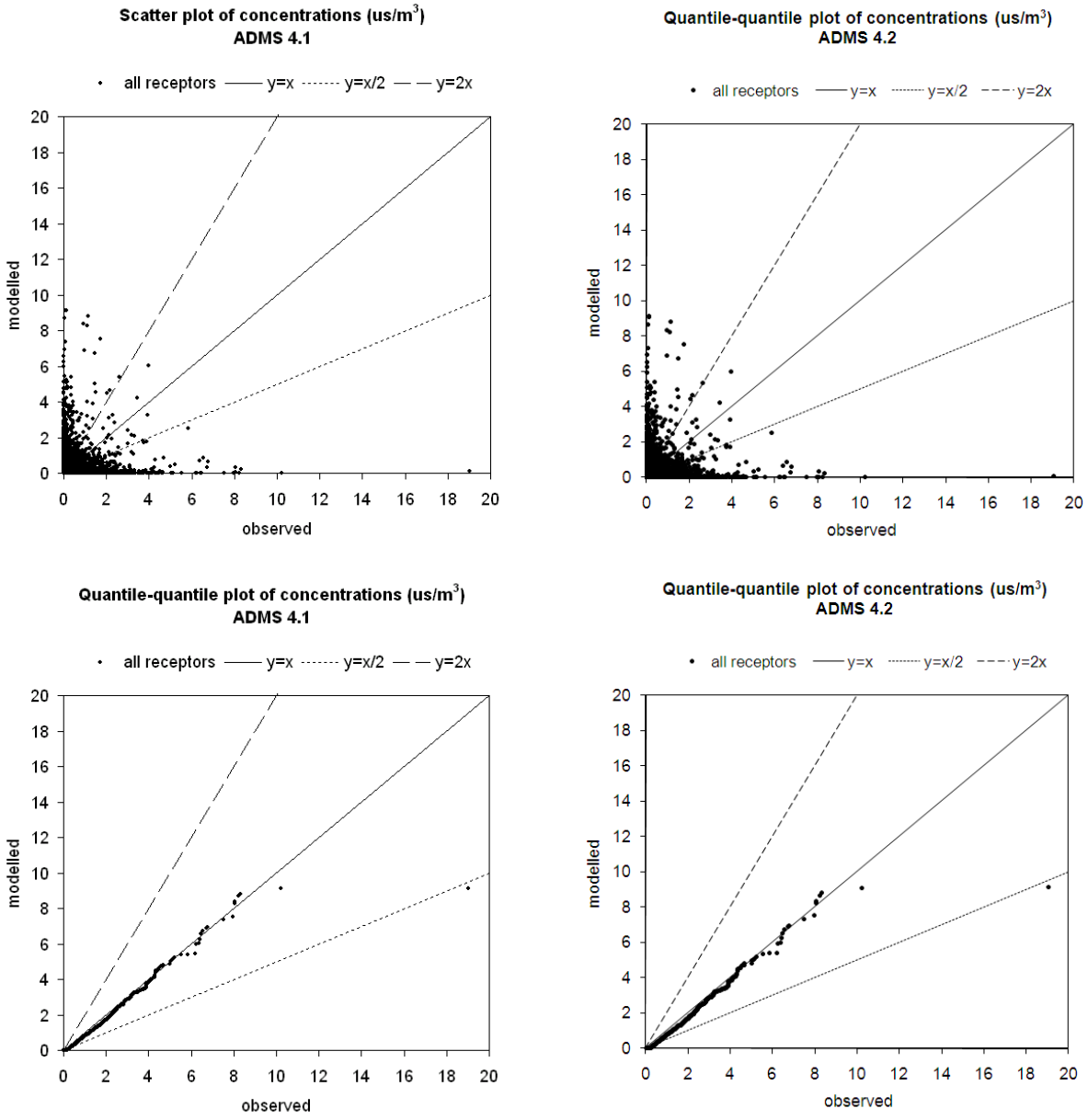

Figure 4 − Scatter plots and quantile-quantile plots of ADMS results against observed data for all receptors (us/m³).

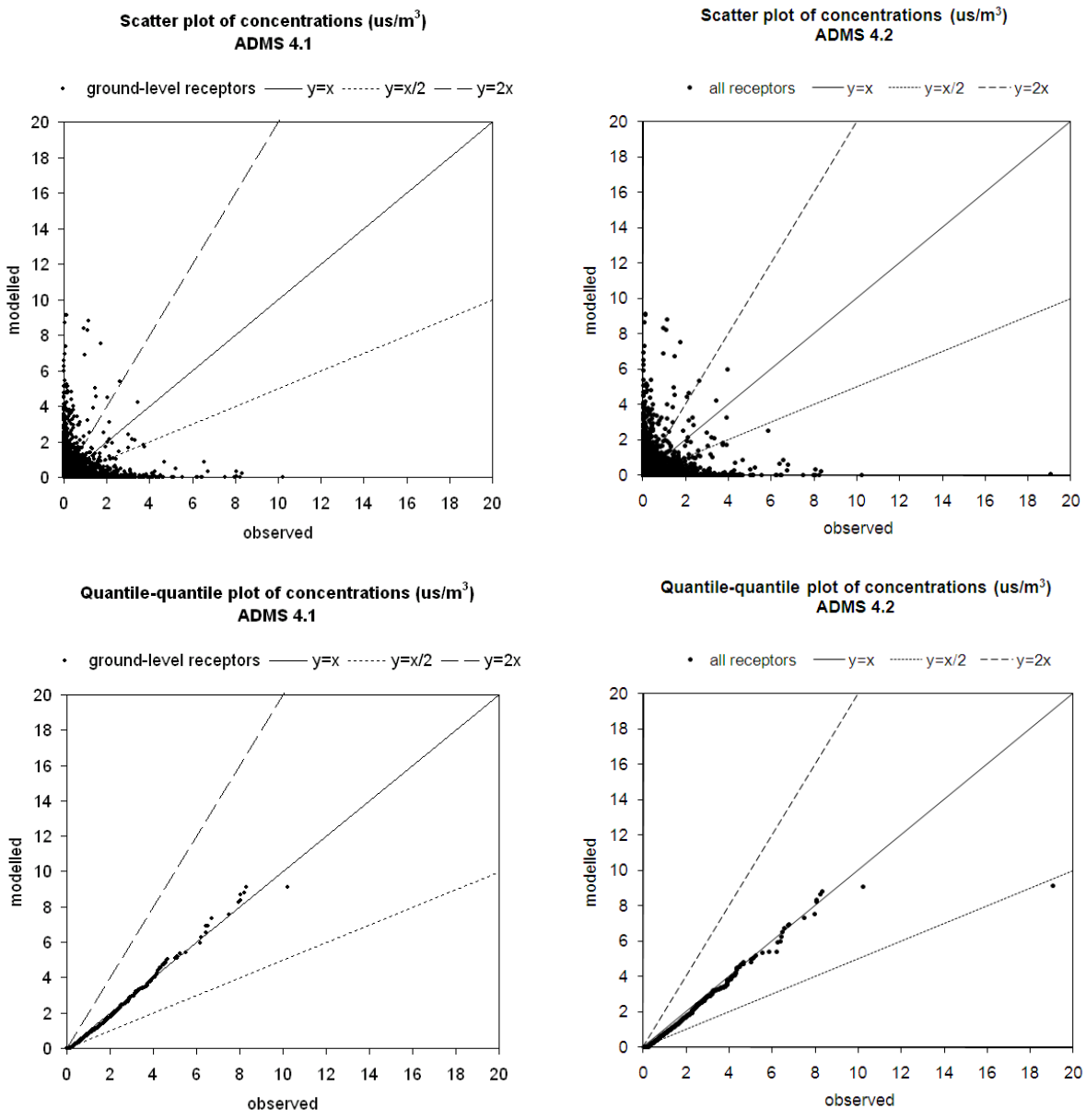

Figure 5 − Scatter plots and quantile-quantile plots of ADMS results against observed data for the ground-level receptors (us/m³).

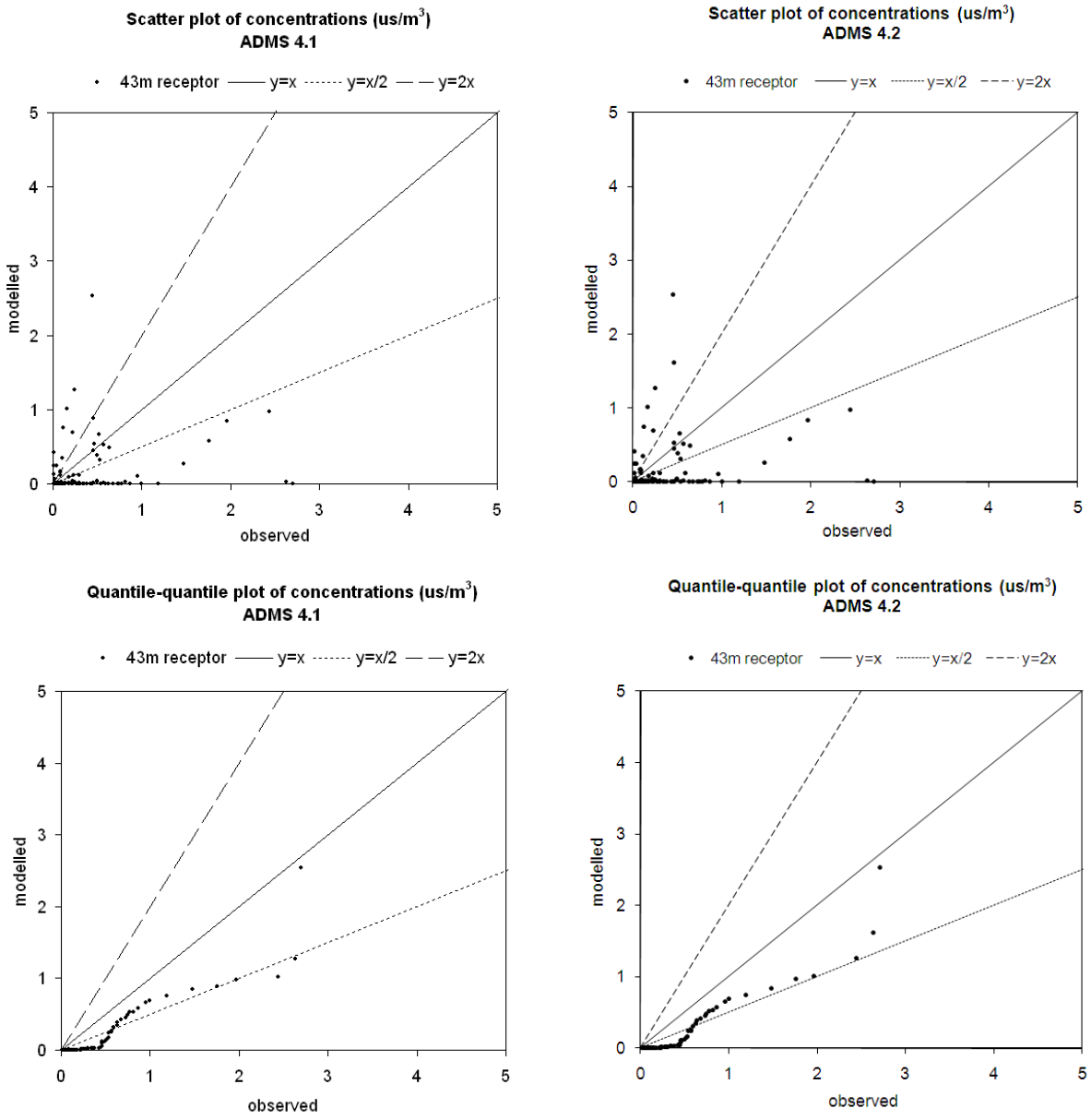

Figure 6 − Scatter plots and quantile-quantile plots of ADMS results against observed data for the 43-m receptor (us/m³).

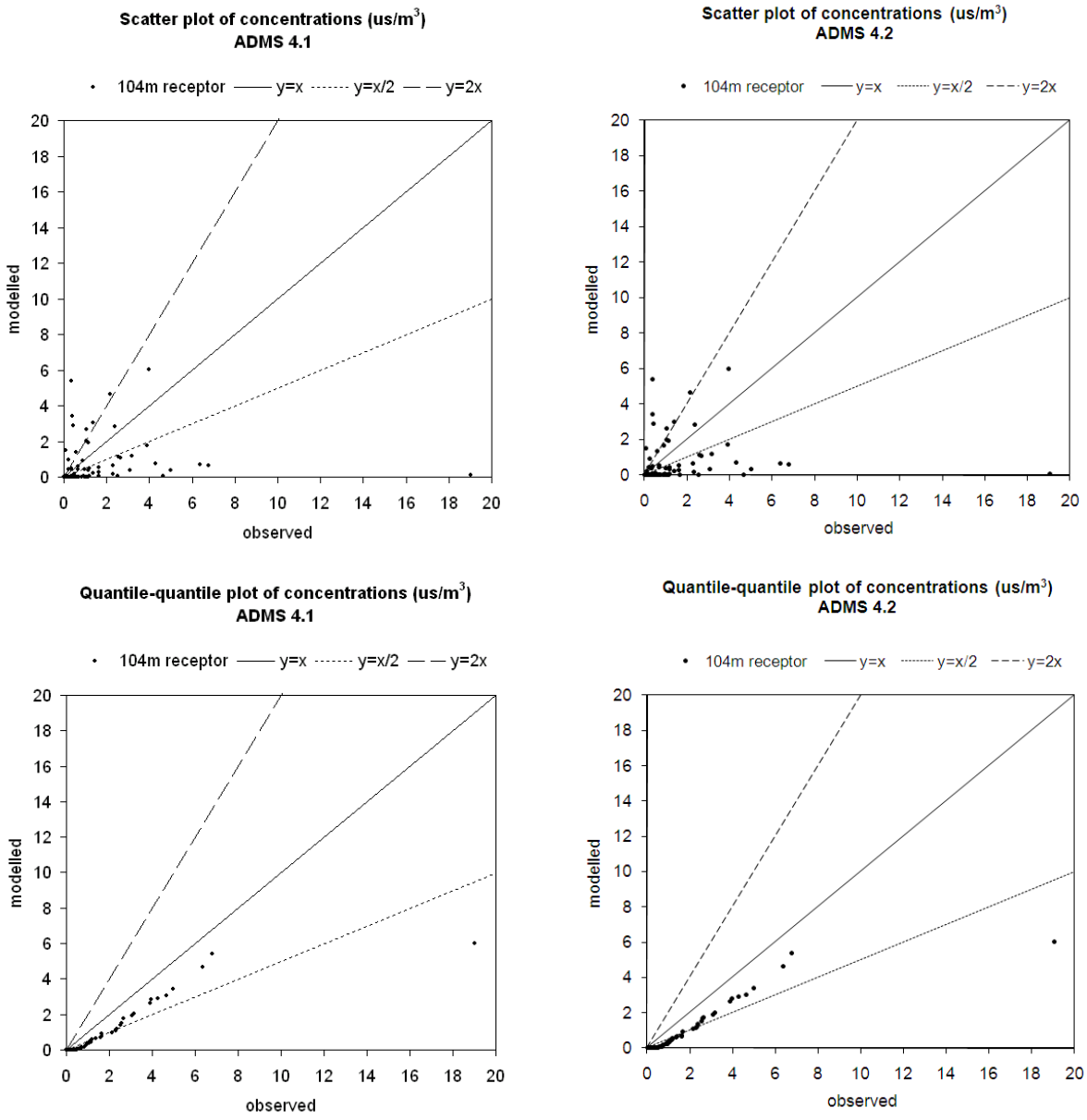

Figure 7 − Scatter plots and quantile-quantile plots of ADMS results against observed data for the 104-m receptor (us/m³).

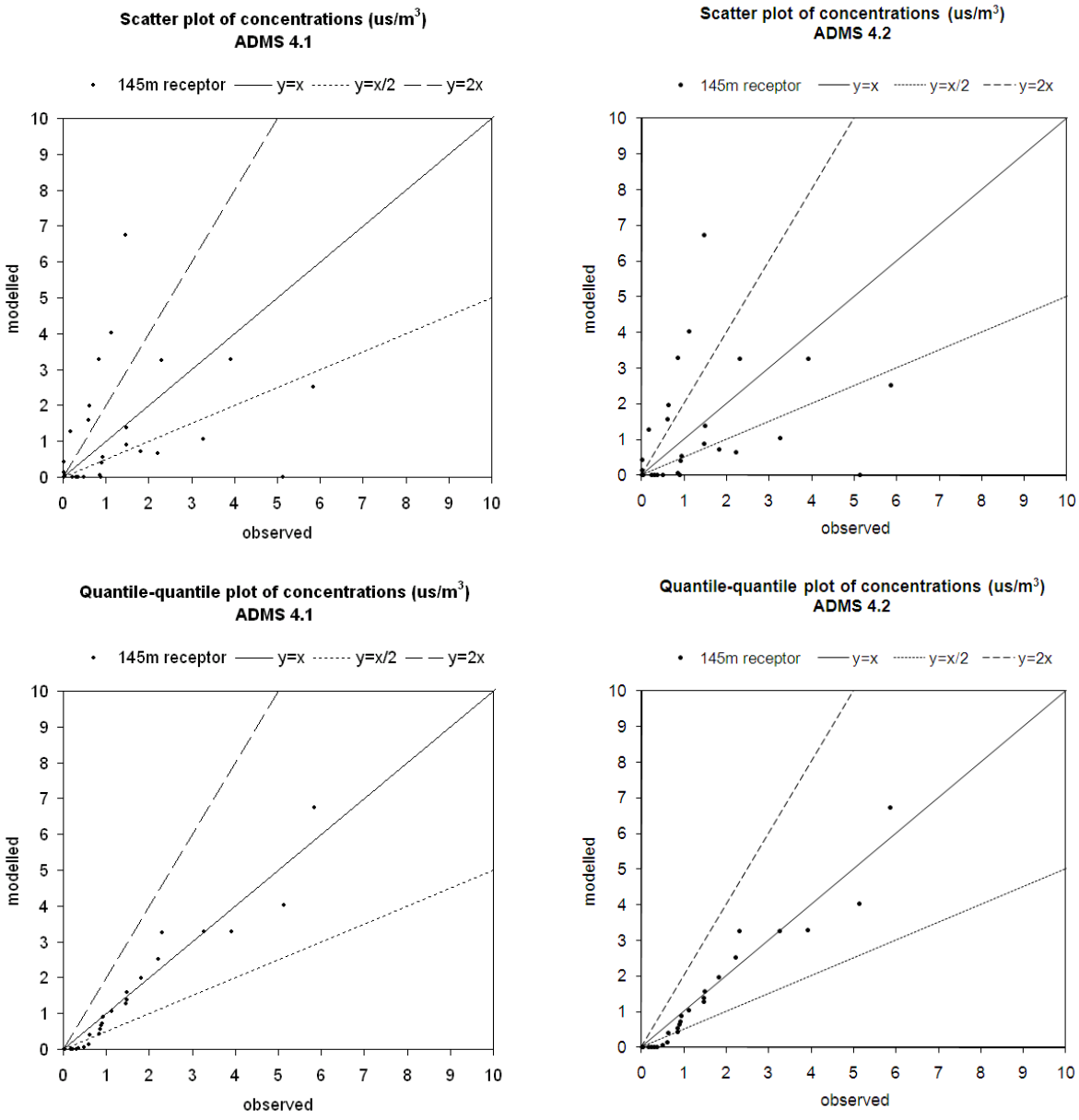

Figure 8 − Scatter plots and quantile-quantile plots of ADMS results against observed data for the 145-m receptor (us/m³).

3.2 BOOT statistics

The BOOT package produces statistics of the data that are useful in assessing model performance. Statistics calculated include mean, standard deviation (sigma), bias, normalised mean square error (NMSE), correlation (cor), fraction of results where the modelled and observed concentrations agree to within a factor of two (fa2), fractional bias (fb) and fractional standard deviation (fs). **Table 2** shows the results from the BOOT package for all receptors, for the ground-level receptors and for each elevated receptor, respectively.

Experiment	Data	Mean	Sigma	Bias	NMSE	Cor	Fa2	Fb	Fs
all receptors	observed	0.23	0.58	0.00	0.00	1.000	1.000	0.000	0.000
	ADMS 4.1	0.15	0.52	0.08	15.67	0.121	0.076	0.416	0.106
	ADMS 4.2	0.15	0.52	0.08	15.54	0.122	0.076	0.406	0.102
ground-level receptors	Observed	0.22	0.53	0.00	0.00	1.000	1.000	0.000	0.000
	ADMS 4.1	0.14	0.50	0.07	15.54	0.097	0.075	0.403	0.046
	ADMS 4.2	0.15	0.51	0.07	15.42	0.099	0.075	0.394	0.041
43-m receptor	Observed	0.39	0.53	0.00	0.00	1.000	1.000	0.000	0.000
	ADMS 4.1	0.16	0.36	0.23	6.20	0.201	0.121	0.827	0.390
	ADMS 4.2	0.17	0.38	0.22	6.04	0.193	0.111	0.783	0.333
104-m receptor	Observed	1.29	2.35	0.00	0.00	1.000	1.000	0.000	0.000
	ADMS 4.1	0.61	1.18	0.69	8.63	0.113	0.112	0.724	0.664
	ADMS 4.2	0.62	1.18	0.68	8.47	0.111	0.112	0.707	0.661
145-m receptor	Observed	1.17	1.47	0.00	0.00	1.000	1.000	0.000	0.000
	ADMS 4.1	1.07	1.55	0.10	2.40	0.344	0.156	0.089	-0.052
	ADMS 4.2	1.07	1.55	0.10	2.40	0.344	0.156	0.088	-0.052

Table 2 − BOOT statistics.

4 Discussion

It should be noted that prediction of hour-by-hour concentrations at a point is difficult, being very sensitive to the precise wind direction during the hour and the monitored concentration is subject to stochastic variation. The models predictions are of the ensemble mean. ADMS has a fluctuations module that accounts for these variations, but this has not been employed in the current results.

The scatter plots compare predicted and measured concentrations at a particular location at a particular time, i.e. an (x,t) pairing. The quantile-quantile plots compare the distribution of predicted and measured concentrations during the period having abandoned the (x,t) pairing. Predicting the distribution of concentrations accurately is relevant to calculations for permitting purposes, where the comparison with air quality limits is more important than accurately predicting a time series of concentrations at each location. The latter is a harder task.

Consideration of the scatter and quantile-quantile plots show that concentrations predicted by ADMS 4.1 and ADMS 4.2 are graphically indistinguishable (see for example the results from

'all receptors', **Figure 4**). Inspection of the BOOT statistics presented in **Table 2** shows that ADMS 4.2 slightly out-performs ADMS 4.1 on almost all statistics.

In addition, an explanation for the less good predictions of concentration at the 43-m height is that the AERMOD meteorological profile data [2] indicates that for a number of hours during the experiment, there was a reverse flow region in the valley. ADMS currently only considers a single wind direction when profile data are used, so the extent of the reverse flow region may not be fully represented in the modelling.

5 References

[1] United States Environmental Protection Agency, 1986: *Description of a Computer Data Base from the Full Scale Plume Study Tracy Power Plant, Nevada.* Atmospheric Sciences Research Laboratory, United States Environmental Protection Agency, Research Triangle Park, North Carolina 27711.

[2] United States Environmental Protection Agency website, *Model Evaluation Databases*. http://www.epa.gov/scram001/dispersion_prefrec.htm

[3] Paine, R.J, Lee, R.F, Brode, R, Wilson, R.B, Cimorelli, A.J., Perry, S.G., Weil, J.C., Venkatram, A, and Peters, W., 1998: *Model Evaluation Results for AERMOD (draft)*. United States Environmental Protection Agency.